

SACCHARUM ROBUSTUM AND OTHER WILD RELATIVES  
OF "NOBLE" SUGAR CANES

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*With three plates*

SINCE 1928, when an expedition led by Dr. E. W. Brandes of the United States Department of Agriculture explored New Guinea in search of sugar canes (5), an unusually large wild relative of the noble or large tropical sugar canes has been known to sugar cane technologists. Living specimens have been distributed to the major sugar cane stations of the world, and sugar cane breeders have utilized them in the development of new commercial sugar canes. During this period, the wild sugar cane in question has been passing under a nomen nudum (*Saccharum robustum*).

The earliest publication in which the name *Saccharum robustum* occurs was by Brandes in 1929 (5). The name was selected by agreement with Dr. J. Jeswiet, who was the first member of the expedition to see this wild cane. Dr. Jeswiet found the green form on the banks of the Laloki River in the Territory of Papua (British New Guinea) (*Pl. III*), and Dr. Brandes shortly afterward found the striking red form on the Sepik River in the Territory of New Guinea (Northeast New Guinea). It was understood that Dr. Jeswiet was to prepare and publish a description of this new species. Dr. Jeswiet, however, never validated this name so far as can be discovered. Numerous discussions of this species have been published by sugar cane technologists, but no botanical description, constituting technical publication, has as yet appeared. This paper has been prepared in order to correct this situation and to present some data with respect to this interesting wild *Saccharum* and closely related grasses. The name consequently becomes:

*Saccharum robustum* Brandes and Jeswiet, sp. nov. PL. I, III.

Perenne. Culmi robusti, erecti vel inclinati usque ad 10 m. alti, glabri, plurinodos, cerosi (infra nodos dense cerosi), diam. 2-3 cm. Foliorum vaginæ hirsutæ usque ad 40 cm. longæ. Ligula brevissima (1.5-4 mm.), membranacea, parum ciliata. Laminæ lineari-lanceolatae, 1.2-2 m. longæ, 3-7 cm. latae, glabrae vel pubescentes, margine serratae. Culmi infra paniculam sparsim appresso-pubescentes. Panicula amplissima, 40-90 cm. longa, effusa; rhachis communis sparsim appresso-sericeo-pubescent. Spiculæ sessiles et pedicellatae similes, 3 mm. longæ, unifloræ. Prophylletum<sup>1</sup> bicarinatum binerve. Gluma prima 1-nervis. Gluma secunda enervis, hyalina, apice ciliata. Gluma tertia absens vel

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tenuis. Palea parvula, hyalina, enervis, apice ciliata. Lodiculae glabrae. Stamina 3. Stigmata purpurea.

An extremely variable perennial, forming compact tufts to large, dense canebrakes up to 10 m. high (in cultivation, culms that flower the first year are 4–5 m. high). Culms are erect or reclining, unbranched, many-noded, green to yellowish brown sometimes tinged with red, 2–3 cm. in diameter, diameter greatest near the nodes in the growth ring (a pulvinar structure above the root band), solid or with a small pith cavity. Rhizomatous or stoloniferous, with stolons long-jointed, flexuous, 1–1.5 cm. in diameter, sometimes creeping for long distances, up to 20 m. The rind of the culms is very hard and woody with a wax coating that is most prominent in a band below the nodes. The root band has 2–5, sometimes more, rows of root primordia and is surmounted by a swollen growth ring which is colored yellowish to red or reddish brown. The leaf-blades are glabrous to finely pubescent, flat, strongly midribbed, linear-lanceolate, 1.2–2 m. long and 3–7 cm. wide, the greatest width of blade about two-thirds of the distance from the base and the margins finely serrulate. The leaf-sheaths are 25–40 cm. long, coarsely hairy, overlapping about 2 internodes and topped by a ligule which is 1.5–4 mm. long. The inflorescence is a large feathery or plume-like panicle, with the branched portion 40–90 cm. long and sparsely short-pubescent. The branches of the panicle are long, slender, jointed, and somewhat fragile, with the spikelets in alternate pairs, one sessile, the other stalked. Disarticulation of rachis occurs below a ring of silky hairs, up to 1 cm. long, which sparsely surround the spikelets; the pedicellate spikelets become free while the sessile spikelets remain attached to the base of a 4–7 mm. long segment of the rachis. Also attached to the base of such rachis segments is a 2–3 mm. long pedicel of the pedicellate spikelet. Spikelets are similar, perfect, about 3 mm. long, with a flower in the axil of the third glume<sup>1</sup> (very rarely with a second flower in the axil of a fourth glume). The prophyllletum is coriaceous, bicarinate with 2 (rarely 4) nerves and a minutely scabrous apex. The first glume is coriaceous, partially enclosed in the wings of the prophyllletum, 1 (rarely 3-)nerved, minutely scabrous at apex and with inrolled, hyaline and ciliate margins. The second glume is hyaline, nerveless, with ciliate margins at apex. The third glume (first lemma) is absent or reduced to a slender, hyaline, minutely scabrous-tipped structure, up to 2 mm. long, and almost hair-like in diameter. The palea is hyaline, nerveless, up to 1 mm. long, with ciliate margins. There are 2 lodicules, not ciliate. There are 3 stamens with anthers about 1.5 mm. long. The pistil has purplish stigmas. The seeds are 1.5 mm. long.

NEW GUINEA: S.P.H.<sup>2</sup> nos. 908, 504, 152, 229, 1097, and 222 from clone 28 N.G.

<sup>1</sup> By third glume is here meant the fourth appendage or first lemma, as the first appendage in the spikelets of Andropogoneae, Tripsaceae, and some Bambuseae is considered homologous with a prophyll and not with the first glume of other grasses. The first appendage in the spikelets of such grasses is here called a "prophyllletum" and the second appendage the first glume.

<sup>2</sup> Sugar Plant Herbarium of the United States Department of Agriculture. The different numbers refer to collections made at different times and places from the clone in question. A living collection of more than 1,000 clones of sugar canes and related grasses is now being maintained at Canal Point, Florida, Summit, Canal Zone, and in part at Beltsville, Maryland. Many of the herbarium specimens referred to in this

251, Imp.<sup>3</sup> 496, found by *J. Jeswiet* on the left bank of the Laloki River near Jail Gardens about 27 km. from Port Moresby, Territory of Papua, June 1928 (TYPE: no. 008 deposited in the U. S. Nat. Herb.); S.P.H. nos. 895 and 1093 from clone 28 *N.G. 104*, Imp. 653, found on the bank of the Kemp Welsh River near Ni-u-iruka, Territory of Papua; S.P.H. no. 1221, coll. by *J. T. Puxley* from Vailala River, Territory of Papua, 1935; in dense pure stands 7-8 m. high on recent silt deposits of the Idenburg River, Netherlands New Guinea, 50 m. alt., coll. by *L. J. Brass*, no. 13791, April 1939; colonizing sand and gravel beaches of the Idenburg River, 850 m. alt., 4 km. s. w. of Bernhard Camp, coll. by *Brass*, no. 13264, March 1939; *C. Boden Kloss*, Camp 1, Nov.-Dec. 1912, 5,000 ft. alt., Utakwa Expedition to Mt. Carstensz, Netherlands New Guinea (Kew Herb.<sup>4</sup>); S.P.H. nos. 904 and 663 from clone 28 *N.G. 218*, Imp. 663, found near Ambunti on the Sepik River, Territory of New Guinea; S.P.H. no. 1519 from clone *Molokai 4730*, Imp. 1027, a selection from seed from the Francisco River, Territory of New Guinea, alt. 3 m.; S.P.H. no. 1520 from clone *Molokai 4826*, Imp. 1028, *ibid.*; S.P.H. no. 1521 from clone *Molokai 5193*, Imp. 1029, a selection from seed collected on the plateau at headwaters of the Ramu River, Territory of New Guinea, alt. 1650 m.

NEW BRITAIN ISLAND: S.P.H. nos. 916, 177, 678, and 1100 from clone 28 *N.G. 289*, Imp. 677, coll. by *C. E. Pemberton* from dry, rocky place near Rabaul; S.P.H. nos. 1101, 178, 679, and 917 from clone 28 *N.G. 290*, Imp. 622, a selection from seed coll. by *Pemberton* near Rabaul.

NEW HEBRIDES: S.P.H. no. 1351 from clone *N.H. 1*, Imp. 933 (vernacular name: *Nassa-u*) obtained near Imera, Efate, by *E. W. Brandes* in 1935; U. S. Nat. Herb. no. 1539004 from Pentecost I., coll. by *A. Morrison*, May 28, 1896 (also seen in Kew Herb.).

The specimen from Pentecost I. is not quite typical in that the inflorescence is somewhat smaller than normal. This may be a smaller form of this species, the introduction of which into experimental cultivation is desirable, as the discovery of a form with a chromosome number of  $2n = 40$  or less would have considerable theoretical interest.

*Saccharum robustum* Brandes & Jeswiet f. *sanguineum* Grassl, f. nov.

*Culmi extus intusque sanguinei.*

NEW GUINEA: S.P.H. no. 1525, 1526, and 1527 from clone 28 *N.G. 219*, Imp. 975, found along the Sepik River near Ambunti, Territory of New Guinea (TYPE: no. 1525 deposited in the U. S. Nat. Herb.); S.P.H. no. 1538 from clone 28 *N.G. 219A*, Imp. 976, found in the same canebrake by *Father Kirschbaum*.

This form differs from the typical form in having a blood red color to the interior of the culms. This color is most intense near the rind and grades off to almost a white in the center of the pith. It is also evident externally in a dark red rind color, deep red buds, dewlaps, and growth rings, and a purplish pink cast to the spikelets.

paper were prepared by Dr. G. B. Sartoris and the late Mr. H. B. Cowgill, while the collection was being maintained in Puerto Rico, and at Arlington Farm, Virginia. Specimens of clones of particular botanical interest can be prepared for exchange.

<sup>3</sup> Imp. — Importation number assigned by Division of Sugar Plant Investigations.

<sup>4</sup> After this paper was submitted for publication an opportunity was had to amend it after examining additional material at the Kew Herbarium and places in England where parts of the herbarium were sent for preservation during the war. The courtesy and assistance extended to me by the Kew Herbarium authorities are gratefully acknowledged.

The types of this form and of the species are specimens from the two largest wild clones of *Saccharum* in cultivation. The importance of this form was immediately recognized by Dr. E. W. Brandes, who found it about 430 km. up the Sepik River in 1928. Special efforts were made to bring it into experimental cultivation at that time, but the original plants died and it was not until almost ten years later, after repeated attempts, that it was established in the living collection of the Division of Sugar Plant Investigations. This was accomplished through the courtesy of the Director of the Department of Agriculture of the Territory of New Guinea, who dispatched a patrol officer to the area on three occasions to get cuttings. A lighter-colored variant of this form was likewise received from who accompanied Dr. Brandes on the Sepik in 1928.

the type locality in 1937 from the late Father Franz Joseph Kirschbaum, The purplish pink cast to the spikelets of the herbarium specimens collected by Brass from the nearby Idenburg River indicates that these may belong to this form or are closely related. Brass does not indicate the color of the culms of the plants from which these collections were made.

Besides the clones of *Saccharum robustum* listed so far in this paper, there are several in our collection that were recently obtained from the Hawaiian Sugar Planters' Association under Molokai numbers. These clones are not referred to in all cases because the preparation of flowering material of some of them was overlooked during the war emergency. Detailed descriptions of the vegetative characteristics of these and others in our collection have been prepared by Artschwager (2). They represent selections from thousands of seedlings grown in quarantine on Molokai Island from seed collected from wild plants in various parts of the Territory of New Guinea (i.e., Northeast New Guinea: Francisco River, alt. 3 m.; Markham River, alt. 150 m.; Bulolo River, alt. 600 m.; Plateau at headwaters of the Ramu River, alt. 1650 m.; and Plateau at headwaters of the Purari River, alt. 1650 m. New Britain: Warangoi and Toriu Rivers, Gazelle Peninsula). A report on the expedition that collected the seed has been published by C. G. Lennox (17).

The presence of *Saccharum robustum* in the Solomon Islands can be expected on the basis of the known distribution. The eastern limit of this species appears to be in the New Hebrides. Plants from Viti Levu, Fiji Islands, which simulate this species will be discussed later in this paper under *Erianthus*.

The distribution of *Saccharum robustum* in Netherlands New Guinea is not well known. What appears to be an illustration of this species is reported by Lam (15, Fig. 25), under *S. spontaneum* L., as growing in large patches along the banks of the Mamberamo River. Herbarium specimens were not collected by Lam (16). His reference to this *gelagah* (4) (Javanese name for *S. spontaneum*) as often being 9-10 m. high is good evidence that it is *S. robustum*. The collections of *S. robustum* by Brass from the Idenburg River, a headwater stream of the Mamberamo

River, is further evidence that the numerous patches of *Saccharum* noticed by Lam along the Mamberamo River belong to this species. Collectors visiting the Mamberamo River, particularly when in the Meervlakte region, should be sure to collect *Saccharum* from the marshy localities also, as *S. spontaneum* can be expected in such habitats. *Saccharum robustum*, from what is known at present, seems to prefer well-drained river-banks.

The occurrence of *Saccharum robustum* or closely related forms west to the Celebes and Borneo seems possible. Wild grasses which may be *S. robustum* have been reported by Bremer (8, 9, 10) under the vernacular names of *Tanange* and *Teboe Salah*. *Tanange* is a vernacular generic name for sugar cane and related wild grasses in the Celebes, while *Teboe Salah* is used for a similar wild grass in Borneo. An attempt to obtain these wild grasses before the Japanese invaded Java was unsuccessful.

Vernacular names have considerable ethnobotanical interest and, consequently, it may not be out of place to note some variations of *Teboe Salah* or false cane. Backer (3, p. 39) refers to *Tebhoe sala* as a vernacular name of *Saccharum spontaneum* in Java, Burkill (12, p. 1924) as *Tebu Salah* under *Erianthus arundinaceus* (Retz.) Jesw. in the Malay Peninsula, and Rumphius (Herb. Amb. 4: 21, t. 6) as *Tubu Sala* under *Arundo farcta* II.

Before discussing the relationships of *Saccharum robustum*, a brief account of what is known of the chromosome number of representatives of this species is presented. Chromosome numbers referred to in this report, unless otherwise acknowledged, are based on unpublished studies in the files of the Division of Sugar Plant Investigations by Ruth C. McGuire (formerly R. C. Starret), assistant cytologist. Chromosome numbers of most of the different clones of *S. robustum* in our collection may be found in the report by Artschwager (2). Of particular interest is the fact that all multiples of 10 from  $2n = 60$  to  $2n = 120$  seem to be represented in this diverse group. The predominant number appears to be  $2n = 80$ , represented by clones from New Guinea, New Britain, and the New Hebrides. Three clones from New Guinea, including the two under forma *sanguineum*, have  $2n = 70$ . Only one in the collection, also from New Guinea, has a count of  $2n = 60$ , which is the same number assigned by Bremer to *Tanange* and *Teboe Salah*. Two clones, including the type, with  $2n = 84$  approximately, are likewise from New Guinea. New Britain Island, besides being represented by two clones with  $2n = 80$ , has one each with  $2n = 90, 100, 110$ , and  $120$ , approximately. In spite of the heteroploidy found in this group, there appears to be no good morphological basis on which more than one species can be recognized.

The closest wild relative of *Saccharum robustum* undoubtedly is *S. spontaneum*. *Saccharum robustum* is distinguished readily from *S. spontaneum*, however, on the basis of the reduced or absent third glume (first lemma) and the sparser and shorter nature of the hairs on the main axis of the inflorescence and subtending the spikelets, as well as by the smaller size of the various spikelet structures. The much larger size of the

inflorescence and of the vegetative structures also facilitate a ready differentiation.

Hybridization between *Saccharum robustum* and *S. spontaneum* appears to be possible, as Brandes and Jeswiet observed intermediate forms and Lennox (17) reported seeing some natural hybrids where these two species occurred close together. A clone in our collection, 28 N.G. 105, Imp. 654, with a chromosome count of  $2n = 140-148$ , from near Ni-u-iruka on the Kemp Welsh River, New Guinea, appears to be somewhat intermediate between these two species. In view of the considerable theoretical interest in the exact nature of hybrids between these species, it seems desirable that artificial hybrids be produced before taxonomic recognition be assigned. Sugar cane breeders who are accustomed to using self- or male-sterile plants as females when making crosses may find it advantageous to try the hot-water emasculation technique, developed by Stephens and Quinby (21) for *Sorghum* hybridization work, when trying to make crosses between self-fertile wild grasses.

In order to clarify the status of *Saccharum spontaneum* in areas in which *S. robustum* has been found, such specimens as are available to me are here cited:

*Saccharum spontaneum* L.

NEW GUINEA: S.P.H. nos. 894, 1092, 651, and 127 from clone 28 N.G. 101, Imp. 652, found near Ni-u-iruka on the Kemp Welsh River, Territory of Papua; S.P.H. nos. 1413, 352, and 1354 from clone 28 N.G. 291, Imp. 875, a selection from seed collected by P. H. Leigh in Eriama swamp about 20 km. from Port Moresby on the road to Rona Falls, Territory of Papua; S.P.H. nos. 1414, 353, and 1355 from clone 28 N.G. 292, Imp. 876, *ibid.*, 13 km. from Port Moresby; S.P.H. no. 223 from along the road between Port Moresby and Rona Falls by Jeswiet, Aug. 7, 1928; S.P.H. no. 1529 from near Sapphire Creek by Brandes & Jeswiet, June 19, 1928; on roadside in savannahs, Rona, Laloki River, alt. 450 m., Brass no. 3528; abundant on alluvial soil of riverbanks in clumps about 2 m. high, Balim River, Netherlands New Guinea, alt. 1600 m., Brass no. 11778, Dec., 1938; very abundant in 2.5-3 m. high thickets on abandoned garden land 18 km. n. e. of Lake Habbema, alt. 2200 m., Bele River, Brass no. 11374 Nov., 1938.

Special attention is called to the collection by Brass from near Lake Habbema in Netherlands New Guinea, as it represents an extremely interesting form of this species. It differs from the typical form of *Saccharum spontaneum* in that the hairs on the main axis of the inflorescence and subtending the spikelets are a straw or brownish yellow color instead of silvery or silky white. Clones with this characteristic color should be brought into experimental cultivation, as a better understanding of the factors involved is likely to solve some of the problems with respect to some of the odd color types of native garden sugar canes that are not explainable on the basis of *S. robustum* forma *sanguineum*. Reference is made to native garden sugar canes which have such straw-colored hairs (clone 28 N.G. 287, Imp. 676, with vernacular name *Huwa*, from Wajake Lo, New Guinea), as well as to others with a brown color to the interior of their culms.

The chromosome numbers of the few clones of *Saccharum spontaneum*

in our living collection from New Guinea are not well understood. The three clones in question have  $2n = 96, 114-116$ , and  $84-88$ , respectively. A fourth clone, 28 N.G. 293, Imp. 877, from the Vailala River, is not considered here because flowering material is not available and the vegetative characteristics are not quite typical. For the benefit of those not familiar with the complexity of this species, it is interesting to note that clones with  $2n = 48, 50, 56, 60, 64, 72, 80, 90, 94, 96, 98, 112, 120$ , and  $128$  supposedly exist (1, 6). The smallest numbers so far discovered are from small plants obtained from the northern extremity of the range of this species along the banks of the Amu Darya in Turkmenistan, the Syr-Darya in Uzbekistan, and near Lahore, India. On the basis of the very small size of some herbarium specimens from China in the U. S. National Herbarium, it is suggested that even lower numbers can be expected when plants of this species from the northern extremity of the range in southern China are examined. Chromosome numbers of forms from the tropics of Africa are not known.

*Saccharum spontaneum* will not be considered further at this time because none of the numerous elements in this extremely polymorphic group appear to have been involved importantly in the origin of the noble sugar canes. Incidentally, they may have been a modifying influence, but only a few of the many native garden sugar canes of New Guinea have some important characteristics in common with this species. The cultivated sugar canes that are most closely related to *S. spontaneum* are those from China and India that are known to sugar cane technologists under the horticultural species *S. sinense* Roxb. and *S. Barberi* Jesw. respectively (6, 14).

Relationship of *Saccharum robustum* to cultivated species of *Saccharum* will now be considered. Of the two horticultural species of *Saccharum*, *S. edule* Hassk. and *S. officinarum* L., which appear to be related to *S. robustum*, *S. edule* will be considered first. *Saccharum edule* is a relatively small group of plants that has never been very well understood by botanists. A reason for this is the absence of specimens in herbaria and botanical gardens. Only eight clones of this interesting group are in our living collection. Seven of these were obtained by the U. S. Department of Agriculture expedition to New Guinea in 1928, while the other clone, *Teboe Troeboeg*, Imp. 724, had been obtained previously from Java. The latter is of considerable botanical interest because it appears to be very similar to, if not identical with, the *trubu* referred to by Hasskarl and Rumphius. A photograph of the abortive inflorescence of *Teboe Troeboeg*, Imp. 724, in a dried condition and of another clone, 28 N.G. 201, Imp. 509, from near Lei, on the north coast of the Territory of New Guinea, in a fresh condition gives an idea of the singular appearance of this horticultural species (Pl. II, figs. 1, 2).

Although the abortive inflorescence of this grass looks somewhat like a banana in the photograph, a resemblance to a mass of small fish eggs apparently led natives to call it *tellor ican*, as listed by Rumphius (Herb.

Amb. 5: 191-192, *t.* 75, *fig.* 1) under *Oya piscium*. Vernacular names now in use for plants of a similar nature are fairly numerous. *Tebu telur* is a Malay name for this plant according to Burkill (12, p. 1929), while Backer (3, p. 40) lists *Teboe telor* (Malayan), *Teboe endog* (Javanese), and *Tiwoc tocroboes* (Sundanese). Bremer (10, p. 154) refers to a *Teboe Tigoe Tenggaron* from central east Borneo as having the cauliflower-like panicle. Vernacular names for clones of this species in New Guinea are much more various. Those noted by the U. S. Department of Agriculture expedition under Dr. Brandes include *Urugu* from the village of Medeni (clone 28 N.G. 38, Imp. 477), *Jahuni* from Jovi (clone 28 N.G. 49, Imp. 639), *Gauka* from Bodogoru (clone 28 N.G. 82, Imp. 647), *Ito* from Ututi, Kikori River (clone 28 N.G. 270, Imp. 669), *Ito Itoika* from Daru (clone 28 N.G. 272, Imp. 670), *Bogo* from Wajake Lo (clone 28 N.G. 286, Imp. 497), and *Apia-Baina* from Bodogoru (not established in our collection).

Detailed descriptions of the vegetative structures of the clones of *Saccharum edule* in our collection have been prepared by Artschwager (2). It is interesting to note that the vegetative characteristics of *S. edule* and *S. robustum* are similar except for relatively minor differences. The leaves of *S. edule*, for example, do not have as hairy a sheath. The blades of many of the clones of *S. edule* are much more densely pubescent, almost velvety, while this characteristic is rare or very much suppressed when not completely absent in *S. robustum* as now understood. Some of the wild canes of Borneo which are reported to be densely pubescent (10) may, however, be found to be referable to *S. robustum* when material becomes available for study.

With respect to the distribution of *Saccharum edule*, it is important to remember that only vegetative means of reproduction can be functional. Furthermore, the dry and pithy culms of this horticultural species make it very difficult to establish it in a new location. This is true particularly if more than a short period of days intervenes between the preparation of cuttings and their planting. Hostility and constant warfare between tribes of Melanesians would further bar the distribution of any but the more easily propagated sugar canes. This would indicate that the present distribution would, for the most part, be similar to or only slightly larger than the distribution of the wild species from which it was derived. The distribution of *S. edule* and of *S. robustum* has not been fully or very accurately determined. We do know, however, on negative but fairly conclusive evidence, that *S. edule*, like *S. robustum*, does not occur on islands east of the New Hebrides. A large grass which is utilized in a similar manner in the Fiji Islands appears to belong to another genus and will be described later in this paper under *Erianthus*.

Some of the consequences of dependence on vegetative reproduction are phylogenetically important. Because of obligatory vegetative reproduction, clones of *Saccharum edule* can be considered as truly ancient plants. Except for the possibility of vegetative mutations, they should be the same as when first discovered, possibly thousands, if not tens of thousands, of

years ago. Consequently, they may have minor characteristics that have long since disappeared from their contemporary wild relatives.

Dependence on vegetative reproduction would also indicate that no single origin would be sufficient to account for the cultivation of this group in which all of the few clones available to us are considerably different. The morphological differences between our eight clones of *Saccharum edule* consist primarily in the distribution of hairs on the prophylls and leaves and in the color, size, and shape of the vegetative parts. The chromosome numbers, which range from about  $2n = 70$  to  $2n = 120$ , are all different except for two that appear to have  $2n = 80$ . Opportunities of improving such sterile plants by vegetative selection over reasonable periods of time appear almost nil. Improvement in such groups is more likely accomplished by new discovery of abortive forms and discarding of the inferior ones.

In view of the complete absence of floral parts in *Saccharum edule*, all evidence with respect to the origin of this group is at present based on vegetative characteristics. These indicate that it is more closely related to *S. robustum* than to *S. spontaneum* or any other wild grass now known from the region in question. This statement could be enlarged to include cultivated grasses as well, specifically the noble sugar canes, since the differences between these two cultivated groups is considerable, even though they are very close relatives of *S. robustum*.

The relationship of *Saccharum robustum* to the noble sugar canes, also referred to as *S. officinarum*, is considerably more complicated than the relationship between *S. robustum* and *S. edule*. This is due to the fact that the noble sugar canes comprise a very complex group. As commonly used, the term "noble sugar canes" includes all large thick-stemmed tropical sugar canes that are cultivated by natives in the western Pacific area and southeastern Asia for chewing purposes. Most commercial sugar canes, nearly all of which have been produced by breeding in quite recent times, as well as the smaller Chinese and Indian commercial sugar canes, are not included in this group, although many commercial varieties have a generous admixture of noble "blood." In recent years, the Latin binomial *Saccharum officinarum* has been generally used for this group, as well as for more or less inclusive groups. Many writers, when referring to cultivated sugar canes of any derivation whatsoever, qualify their first reference to sugar canes by this name. In contrast to this broad interpretation, the very careful Dutch sugar cane technologists (8, 10, 14, 19) set up narrower and narrower limits to this group until Bremer (9) concluded that only noble sugar canes with  $2n = 80$  chromosomes were *S. officinarum* and all the others were hybrids.

Unfortunately, the group in question is not as simple as this would imply. Many more noble sugar canes have been brought into experimental cultivation since Bremer came to his conclusions. An examination of some of these indicates that a further qualification is necessary if we are to accept his conclusions. This qualification would be that only a part

of the noble sugar canes with  $2n = 80$  chromosomes are similar to the group he had in mind. This statement is based on observations of some 72 clones of noble sugar canes in the living collection of the Division of Sugar Plant Investigations with  $2n = 80$  chromosomes. Some of the clones with this number of chromosomes from Hawaii and New Caledonia do not seem to belong in this group. Reference will be made to them under the discussion with respect to relationships with *Erianthus maximus*.

The importance of the work of Bremer and other Dutch technologists in calling attention to this group lies in the fact that it has brought sharply into focus what undoubtedly is the most important element in the great diversity of forms collectively known as cultivated sugar canes. The group in question — represented by such clones as *Batjan*, *Black Cheribon*, *Crystalina*, *Fiji*, *Gestreept Preanger*, *Olahcite*, and *Simpson* and seedlings of these as *B.H.* 10/12, *D-74*, *E.K.* 2, *S.W.* 3, *D.I.* 52, etc. —, although small in number, has been the backbone of the sugar industry since the last years of the Eighteenth Century, when the historic clone now known as *Creole* began to be displaced in the Western Tropics. Even now, sugar cane breeders still find it necessary to backcross to elements of this group when they wish to obtain high sucrose and low fiber varieties.

In view of the great importance of the group referred to in the above paragraph, it appears desirable to follow the lead of the Dutch workers and at least recognize this group as the basic element of *Saccharum officinarum*, if not necessarily the only element. No type specimen of *S. officinarum* exists (18), and following customary botanical procedure might lead to absurdities, as the only sugar cane extensively grown in southern Europe and the Western Hemisphere at the time of the formation of this binominal and for centuries before was the clone called *Creole*, which appears to be a very odd hybrid type with  $2n = 81$  chromosomes. The designation of a lectotype for this horticultural group — *S. officinarum* — might best be delayed until further material becomes available and more detailed studies, particularly cytogenetic, have been undertaken. When reference is made hereafter to *S. officinarum* in this paper, it is to be interpreted as meaning the sugar cane clones mentioned in the preceding paragraph.

A monograph of the cultivated sugar canes is not yet possible because many areas (Easter Island, Marquesas Islands, Solomon Islands, Spice Islands, Borneo, Malay Peninsula, Indo-China, to mention only the most important) have not been adequately searched for representative groups of garden sugar canes, and they represent gaps in our collection of important geographic groups. Furthermore, many of the sugar canes already in experimental cultivation are not represented by flowering material in any herbarium. Only about 200 native garden sugar canes are represented by flowering material in the U. S. Sugar Plant Herbarium. There may have been a more extensive collection, particularly of the Netherlands Indies forms, at the Eastern Java Experiment Station. Coöperation between the various sugar cane stations will again be necessary to advance

these studies rapidly on a broad front. The flowering of many sugar cane clones is very erratic, and therefore progress in obtaining flowers is accelerated by teamwork under different environments. An added reason for close collaboration is that a clone under a given name at one station may be totally different from a clone under the same name at a different station. Moreover, identical clones may be carried at two or more stations under different names.

*Saccharum officinarum* is considerably different from *S. robustum*. The vegetative characteristics of *S. officinarum* will not be considered here because they have been influenced radically by the selective ability of primitive horticulturists and consequently do not help very much in determining relationships. The floral parts of *S. officinarum*, in contrast to those of *S. edule*, have not been utilized by primitive man, and they consequently are not consciously modified but give valuable indications as to relationships. Taken by themselves, the floral parts of the group of noble sugar canes called *S. officinarum* are readily distinguished from similar parts of *S. robustum*. The inflorescence, as a whole, is shorter, broader, and coarser. The rachis segments are stouter and not as long relatively with respect to the size of the spikelets. The spikelets of *S. officinarum* are easily distinguished from those of *S. robustum* in that all the parts are slightly larger. Accompanying this increase in size of the spikelet parts is an increase in the number of vascular bundles in some of the parts. The prophyllletum of *S. officinarum* generally has 4 rather than 2 veins as in *S. robustum*. The first glume has 3 veins rather than 1, whereas the second glume has 1 in contrast to none. Only the third glume is similar in that it is absent or greatly reduced in both groups. On the basis of these morphological differences the relationship between *S. robustum* and *S. officinarum* is not very close.

The principal evidence for any relationship whatever between *Saccharum officinarum* and *S. robustum* is based on limited cytogenetic data on hybrids between members of these groups. Hybridization between *S. officinarum* and *S. robustum* is readily accomplished by using *S. officinarum* as the female parent and results in  $F_1$  seedlings that have a larger chromosome number than the sum of the monoploid numbers of the parents (6). The increase in chromosome number beyond the sum of the monoploid numbers of the parents is only about one-half as great as when *S. spontaneum* is used as the male parent and, consequently, it is surmised that *S. officinarum* and *S. robustum* possibly have as many as 20 chromosomes in common. More work in this direction is indicated, using clones of *S. robustum* with  $2n = 60, 80$ , and  $100$  chromosomes.

Of considerable interest with respect to relationships between *Saccharum robustum* and noble sugar canes other than *S. officinarum* are the numerous clones obtained in native gardens in New Guinea by the U. S. Department of Agriculture expedition of 1928. Morphologically many of the clones of noble sugar canes from New Guinea are so similar to *S. robustum* in floral characteristics that differentiation on this basis alone is very difficult

if not frequently impossible. The same, however, may be said of the hybrids between *S. officinarum* and *S. robustum*. The problems presented by this resemblance are of great interest and importance. What one would like to know is whether these clones are all hybrids between *S. officinarum* and *S. robustum* or if some of them are direct derivatives of *S. robustum*. Clones in which hybridization with *S. spontaneum* may have been involved introduce complicating factors but are more readily differentiated from the others. The complexity of the situation results from the ease with which hybridization takes place between the several groups in question. Answers may be forthcoming when additional material becomes available and further studies are made. Collectors of native sugar canes may help appreciably in the solution of some of these problems by giving special attention to the most inferior types available, as these are most likely to be missing links in the complicated history of sugar cane origins and the first to be discarded by the natives when modern improved varieties become available to them.

A partial clarification of the relationships of *S. officinarum* has resulted from a detailed study of numerous noble sugar canes from Micronesia and Polynesia. These groups are of particular interest because they are so obviously different from the large collection of noble sugar canes from New Guinea. Whereas only a very small percentage of the New Guinea noble sugar canes are similar to the clones of *S. officinarum*, practically all of the noble sugar canes now available from east of the New Hebrides have many morphological characteristics in common with *S. officinarum*. In fact, unpublished notes indicate that the floral characteristics that differentiate *S. officinarum* from *S. robustum* are frequently accentuated in clones of noble sugar canes from this area.

The most significant discovery in the present investigation is that many of the original noble sugar canes from Hawaii have a small awned third glume. The third glume is normally absent from *Saccharum officinarum* and *S. robustum*. Many of the clones in question are also different in that they are morphologically sterile. The prophyllletum and glumes, including an awned third glume, are present and apparently normal in every respect, but all the other spikelet structures—palea, lodicules, anthers, and pistil—are absent, except for minute primordia, as in *S. edule* and a species of *Erianthus* (Pl. II, fig. 3) described hereunder. The awn, small but very distinct in structure, is important because it verifies to a great extent a conclusion with respect to the origin of *S. officinarum*, which previously had been surmised (7). On page 149 of that paper it was suggested, on the basis of similarity in the morphology of floral structures, that *Erianthus maximus* Brongn. "is in many respects the most likely species of *Erianthus* that may have played a part in the origin of the large cultivated canes."

The evidence points to *Erianthus maximus* as the second important wild relative of the noble sugar canes. Before discussing the relationship of this species to the noble sugar canes, specimens familiar to me are here cited:

*Erianthus maximus* Brongn. in Duperr. Voy. Coq. Bot. 2(2): 97. 1831.

*Saccharum pedicellare* Trin. in Mém. Acad. St. Pétersb. Math. Phys. Nat. 2: 310. 1832.

SOCIETY ISLANDS: Tahiti, *W. A. Setchell & H. E. Parks* no. 535, July 8, 1922, 18–20 feet high in large clumps in openings on moist slopes on the face of the Diadem, alt. 2500 ft.; S.P.H. nos. 1337 and 1425 from clone *Tahiti-7*, Imp. 852 (in mosaic collection only), vernacular name *Oviri*, from Atimaono, Tahiti, collected by *E. W. Brandes* in 1935; S.P.H. nos. 1353 and 1513 from clone *Raiatea 1*, Imp. 923, from valley, alt. about 600 ft., Raiatea, by *Brandes*.

AUSTRAL ISLANDS: Raivavae, Mt. Muanui, south slope, ravine at edge of forest, alt. 150 m., ascending 2 m. high, sap somewhat sweet, *F. R. Fosberg* no. 11694, Aug. 8, 1934 (mixture of two kinds—typical *E. maximus* and a noble sugar cane—of which only small fragments were seen at the U. S. Nat. Herb.); Rapa, Hiri Valley, bank, by taro patch, apparently cultivated, alt. 50 m., decumbent, plant 3, *H. St. John & Jean Mairean* no. 15633, July 20, 1934.

COOK ISLANDS: *T. F. Cheeseman* no. 719, June 1899, Rarotonga (Kew Herb.).

NEW CALEDONIA: *M. Vieillard* no. 1510, Mt. Panoin, Gatope (Kew Herb., listed by Balansa and Guillaumin as *Saccharum officinarum*); S.P.H. nos. 1514 and 1518 from clone *N.C. 1*, Imp. 1004, originally from near Noumea, by *Brandes*; S.P.H. nos. 1335, 1515, and 1516 from clone *N.C. 132*, Imp. 921, originally from east coast near Kanala, by *Brandes*.

Fiji ISLANDS: *J. Horne* no. 701, 1877–78, the wild red and the white “*vico*” (two sheets in Kew Herb. with notes similar to quotation from 13, p. 69, cited below); *B. Seemann* no. 691, 1860 (as *Eulalia japonica* Trin. in Seem. Fl. Vit. 321, consists of two sheets in Kew Herb., of which one appears to be leaves of *E. maximus* while the other is an immature inflorescence of what appears to be a noble sugar cane); S.P.H. no. 1346 from clone *Fiji 2*, Imp. 861, originally from Nausori, near Suva, Viti Levu, by *J. Matz*, through the courtesy of the Colonial Sugar Refining Co.; S.P.H. nos. 1347 and 1517 from clone *Fiji 3*, Imp. 862, originally from Rarawai, Viti Levu, by *Matz*.

Besides the clones cited, there are six clones in our collection from Viti Levu, Fiji Islands, that are so similar to *Fiji 2* and *Fiji 3* in vegetative characteristics that they must be considered as cultivated derivatives of *Erianthus maximus*. Specimens of the inflorescence of most of these clones are not available as yet and, consequently, they will not be discussed in detail. They are of particular interest because they are the *Duruka* (also *Drauka* and *Daruka*) canes that simulate *S. robustum* so closely in their stem characteristics.

The *Duruka* canes were obtained through the courtesy of the Colonial Sugar Refining Co. The following quotation from a letter with respect to them from Mr. V. Mott is of considerable interest: “The derivation of “*Duruka*” is not known—“*Vico*” by itself means a field of tall grass—“*Duruka Vico*” is a tall cane-like grass that flowers, in contrast with the other varieties of *Duruka* which produce edible heads only . . . The Fijians state that they have never used the *Duruka* juices for sweetening purposes in their cooking, hence apparently the name “*Duruka*” as distinct from the sweeter canes named “*Dovu*.”

“There are known to be nine different varieties of native cane, called *Duruka*, growing in Fiji: they are called by the natives *Duruka Kibo*, *D. Leka*, *D. Coqocoq*, *D. Toci*, *D. Veirai*, *D. Mirimanu*—producing “cauliflower” edible heads instead of tassels—and *Duruka Vico Vula* (*Vula* =

white), *D. Vico Damu* (*Damu* = red) and *D. Vico Teiniloka* (*Teiniloka* = bronze) producing flowering tassels."

The abortive types of *Duruka* were referred to by Horne (13) in 1881. On page 91 he gives the following account of this unusual vegetable: "Another gramina, the *drauka*, a plant somewhat resembling the sugar cane, is cultivated largely in some parts of Fiji. As a vegetable it is much relished by the Fijians all over the group. The unexpanded panicle of young flowers is the part eaten. If taken when young and tender, properly cooked, and served with butter as sauce, it is reckoned, by some, not inferior to asparagus. I regret that my specimens of this plant were not in fit condition to be named. They were not sufficiently advanced, and from the demand for the flowering shoots, specimens in full flower could not be obtained. To obtain these in Fiji, a *tabu* or prohibition to touch, would require to be put on a few plants."

Horne apparently did not realize that the flower parts of the kinds that are eaten do not mature. The closely related kinds, such as *Fiji 2* and *Fiji 3*, that flower are extremely tough and fibrous in the boot stage and could not be considered edible except possibly when the inflorescence is in a minute primordial stage. The clones which flower enable us to be fairly certain that this group of grasses is primarily a derivative of *Erianthus maximus*. Hybridization, particularly between diverse forms of *E. maximus* or between such forms and noble sugar canes, undoubtedly was a dominant factor in the origin of the various clones in this group. Inasmuch as there cannot be any certainty about the origin of such a group and because of its unique character, it is desirable that it be given a horticultural name. The name proposed for this group is as follows:

*Erianthus maximus* Brongn. hort. var. "ABORTIVE." PL. II, FIG. 3.

Fiji ISLANDS: S.P.H. nos. 1522 and 1523 from clone *Fiji 1*, Imp. 860, originally from Nausori, near Suva, Viti Levu.

It is not known if *Fiji 1* is identical with any of the *Duruka* clones not in our collection. The two *Duruka* clones in our collection that belong to this horticultural group — *Duruka Mirimanu*, Imp. 1021, and *Duruka Coqecoqe*, Imp. 1020 — are distinct clones. Detailed descriptions of the vegetative characteristics of the clones in our collection belonging to this group have been prepared by Artschwager (2).

The wild and cultivated forms of *Erianthus maximus* have long been mistaken for wild sugar canes. Horne is only one of many who was confused by this species of grass. The following account by Horne (13, p. 69) with respect to this group of plants in the Fiji Islands is of interest: "Sugar canes *dovo* (*Saccharum officinarum*), are common; both wild and cultivated varieties. The wild varieties grow in dense brakes on the rich alluvial flats and along the sides of small rivers and streams. They frequently grow to a height or length of about 20 feet, with a diameter varying from one-fourth of an inch to an inch. They are of various colours, green, white, or red, and some varieties are striped like a ribbon. The juice of some of the varieties has a faint sweet taste, but that of the

majority is insipid and watery. Their characters at once suggest them to be the plants from which the cultivated varieties of the sugar cane have descended by improvement on successive sorts from a distant period. Improvement on them will be tried in the Botanical Gardens at Mauritius."

The origin of *Saccharum officinarum*, unfortunately, is not as simple as Horne suggests. *Erianthus maximus* is different from *S. officinarum* in many respects. Besides the differences already mentioned, the differences in floral characteristics are most important. The spikelets of *E. maximus* are in every respect larger than those of *S. officinarum*. This also holds true for all the spikelet parts. The difference in size is considerable in that the parts are almost twice as large as corresponding parts of *S. robustum*. With respect to size of spikelet structures, *S. officinarum* appears to be somewhat intermediate between *E. maximus* and *S. robustum* but closer to *S. robustum*. Besides the difference in size of floral structure, not many differences exist between the floral structures of *Erianthus maximus* and *Saccharum officinarum*. The venation of the spikelet structures of *E. maximus* is fairly similar to that of *S. officinarum*. The veins are generally more distinct and the prophyllletum sometimes has one or two additional veins, making a total of 5 or 6 instead of 4. A significant difference is found in the third glume, which is awned in *E. maximus* and generally absent in *S. officinarum*. Awnedness, however, is very likely recessive to absence of third glume. The length of the awn in *E. maximus* varies considerably (11). In the clones from the Fiji Islands and New Caledonia, the awn is greatly reduced and generally does not even extend to the tip of the glumes. Another difference is found in the lodicules, which are very large with numerous cilia along their upper edge in *E. maximus*. In contrast to this, the lodicules in *S. robustum* are very small and not ciliate, while *S. officinarum* may or may not have cilia at each end of the upper edge of this wedge-shaped structure. The fairly frequent occurrence of a second flower in the axil of a fourth glume in the spikelet of *E. maximus* is a character that only rarely occurs in *S. officinarum* or *S. robustum*.

The chromosome number of the various clones of *Erianthus maximus* is of interest. All multiples of 10 from  $2n = 60$  to  $2n = 100$  are represented. Clone *Raiatea 1*, Imp. 923, from the Society Islands, has a chromosome number of  $2n = 60$ . *Tahiti 7*, Imp. 852, has about  $2n = 70$ . *N.C. 132*, Imp. 921, from New Caledonia, as well as *Duruka Vico Vula*, Imp. 1017, and *D. V. Teiniloka*, Imp. 1019, from the Fiji Islands, have  $2n = 80$ . *Fiji 3*, Imp. 862, has  $2n = 90$ , while *Duruka Vico Damu*, Imp. 1018, also from Fiji, has  $2n = 100$ . *N.C. 1*, Imp. 1004, from New Caledonia, may have  $2n = 90$  or 100, as this originally was a mixture of two clones of which one part was accidentally discarded and a new count of the remainder has not been completed. The closely related clones of *Erianthus maximus* Brongn. hort. var. "Abortive" have a chromosome number of  $2n = 70$  for *Fiji 1*, Imp. 860, and  $2n = 80$  for *Duruka Coqecoqe*, Imp. 1020, and *Duruka Mirimanu*, Imp. 1021.

Before discussing further the relationship of *Erianthus maximus* to the

noble sugar canes, it should be pointed out that *E. maximus* is not very closely related to *E. arundinaceus* (Retz.) Jesw., *E. sara* (Roxb.) Rumke (20), and the other species of *Erianthus* of the Eastern Hemisphere. The closest wild relative of *E. maximus* appears to be *E. Trinii* (Hack.) Hack. of Colombia, Brazil, and Paraguay. The *Erianthus* on Easter Island has not been seen by the writer of this paper. *Erianthus maximus*, as here interpreted, has been reported from Samoa and the Marquesas, but not from any area in which *S. robustum* is known to occur.

Artificial hybridization of *Erianthus maximus* and *Saccharum officinarum* or *S. robustum* has not been accomplished so far as is known. It may be necessary to import additional clones before such crosses can be made under conditions in southern Florida, where sugar cane breeding of the Division of Sugar Plant Investigations is conducted. The introduction of clones from such places as Samoa, Austral Islands, and the Marquesas is indicated in any event. The absence of artificial hybrids between *E. maximus* and *Saccharum* makes it difficult critically to evaluate the numerous noble sugar canes from Micronesia and Polynesia, as well as from New Caledonia, which are obviously different from *S. officinarum* as here narrowly interpreted.

On a strictly morphological basis it would seem that many of the noble sugar canes from this area are intermediate forms. Evidence for the assumption that many noble sugar canes are intermediate between *Saccharum officinarum* and *Erianthus maximus* is not as definite as is desired. The most convincing evidence is the presence of a small-awned third glume in some of the noble sugar canes in question. Others have larger pistils and a greater number of spikelets with two florets than one normally finds in *S. officinarum*. Six of about 40 Hawaiian original sugar canes have pinkish lavender midribs in their blades, whereas only two of more than 150 from New Guinea, namely, 28 N.G. 13, Imp. 632 (a reddish purple leaved sugar cane called *Ure* from Abam, Oriomo River, New Guinea, which is very much like *Ireng Malang*, Imp. 1062, *Tomohon Zwart*, Imp. 1090, and *Boetota Bilatoe*, Imp. 1052, in this respect), and 28 N.G. 38, Imp. 477 (*S. edule*) have this character. Of the few clones of *E. maximus* in our collection, *Fiji 2*, Imp. 861, and *Duruka Vico Teiniloka*, Imp. 1019 — likewise *Duruka Mirimanu*, Imp. 1021 (*Erianthus maximus* Brongn. hort. var. "Abortive") — have pinkish lavender midribs. *Duruka Vico Teiniloka*, Imp. 1019, has, in addition, the reddish purple leaves of 28 N.G. 13, Imp. 632. The sheaths of the majority of the noble sugar canes from Polynesia, Micronesia, and New Caledonia are surprisingly free of coarse hairs, whereas those from New Guinea are in many cases very hairy. *Erianthus maximus*, from Fiji and New Caledonia, generally has smooth sheaths, or the hairs that develop are immediately deciduous on protrusion of a sheath from the sheaths below. Clones of *E. maximus* from the Marquesas and *Raiatea 1*, Imp. 923, from the Society Islands, have irritating hairs on the sheaths. Other resemblances and differences will undoubtedly be found as progress is made in the understanding of these complex groups.

On the basis of the morphological and geographical evidence presented in this paper, it is suggested that noble sugar canes are most closely related to *Saccharum robustum* and *Erianthus maximus*. There may have been separate origins of sweet forms in both of these groups, but it seems more likely that the main origins were from *S. robustum* and that as these forms were carried eastward beyond the range of wild *Saccharum* they were modified by hybridization with forms of *E. maximus*. The area in which this modification primarily took place appears to be the Fiji Islands and New Caledonia. Some of the modified forms were found to be superior and were carried back to New Guinea and other areas where *S. robustum* occurred and backcrossing took place. Clones that were carried to areas such as Hawaii in Polynesia apparently inbred, and some of the characteristics which appear to have been obtained from *E. maximus* were accentuated.

Comparative observations of a large number of original sugar canes and related wild forms thus far has permitted considerable advance along the road toward elucidation of the origins of sugar canes. It has become apparent in this study that progress is more certain when all available garden canes and related feral types of an island or region are assembled to compare with similarly complete assemblages from other islands or regions. Individual varieties or limited samplings from a given region are not satisfactory. Fortunately, some of the regional collections have been on a generous basis. They prove that there are a number of geographic points of origin and satellite regions of modification shown by distinctly different group compositions in different areas.

The story of sugar cane origins is by no means told. Critical cytogenetic studies of the complex groups involved remain to be made in testing the suggestions advanced in this paper. The high chromosome numbers found in noble sugar canes and related grasses is a very discouraging factor, which may long delay a better understanding of the plants in question. Another hindrance to rapid progress in the theoretical aspects of the problems of origins of sugar canes is the outbreeding normally practiced in the development of garden forms and new commercial sugar canes.

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## EXPLANATION OF PLATES

## PLATE I

*Saccharum robustum* Brandes and Jesweit. FIG. 1. *A*. Seeds of forma *sanguineum* Grassl. *B*. Anthers. *C*. Pedicellate spikelet. *D*. Rachis segments with spikelets. *E*. Margin of leaf-blade from a clonotype. *B*, *C*, and *D* are from the type of *S. robustum*. FIG. 2. Type of *S. robustum*, deposited in the U. S. National Herbarium. Note that two herbarium sheets are required to accommodate the 65 cm. long tassel. FIG. 3. *A*. Pistil. *B*. Third glume (first lemma) from a topotype. This structure normally is not as long, 1.5 mm., as this example. The dissection of 20 spikelets from the type specimen of *S. robustum* did not reveal any structure in the position where this third glume should be when present. *C*. Lodicules. *D*. Palea. Paleas of *S. robustum* frequently are shorter and broader with more cilia toward the apex. *A*, *C*, and *D* are from the type of *S. robustum*.

## PLATE II

FIG. 1. *Saccharum edule* Hassk., clone *Teboe Troeboeg*, Imp. 724, showing the aborted inflorescence and the flag leaf in a dried condition. The cauliflower-like inflorescence remains enclosed within the sheaths of the upper 3 or 4 leaves. FIG. 2. *Saccharum edule*, clone 28 N.G. 201, Imp. 509, showing the aborted inflorescence in a fresh but slightly overripe condition, as indicated by the discoloration at the apex. A customary way of preparing this vegetable for consumption is by roasting. FIG. 3. *Erianthus maximus* Brongn. hort. var. "Abortive," clone *Fiji 1*, Imp. 860. Note that the suppression of development of the inflorescence is not quite as complete as in *Saccharum edule*.

All photographs of Plates I and II are by P. St. C. Browne except Fig. 2 of Plate II, which is by J. F. Brewer.

## PLATE III

UPPER. Clump of *Saccharum robustum*. Territory of Papua, left bank of Laloki River, the type locality. (Photo by E. W. Brandes.) LOWER. Creeping culms or rhizomes of *Saccharum robustum*, some partly exposed and showing rooted, leafy shoots. The rhizomes sometimes extend 60 feet from the base of an erect stool. Strickland River, Territory of Papua. (Photo by J. Jeswiet.)

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